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Description

The invention concerns a method for automatically correcting the zero drift of a pressure transducer including the steps of automatically connecting the transducer to a reference pressure, measuring said reference pressure, using the measured value for generating a correction factor and applying said correction factor to subsequent readings of said transducer.

The invention further concerns an apparatus for automatically correcting zero drift of a pressure transducer comprising a valve, connecting in a first position the pressure transducer to a pressure to be measured and connecting in a second position the pressure transducer to a reference pressure device, control means actuating said valve means for recording the measured pressure value in said second position and means for generating a correction factor.

From the US—A—4 051 712 such a method and an apparatus is already known. This known system uses a reference pressure, which is selected to be in the operating range of the transducer. In order to obtain the correction factor, it is necessary to put in a reference voltage. The value of this voltage corresonds to a value which said transducer produces if it should measure without zero drift the actual pressure in a reference pressure chamber.

As a consequence, there are two important presuppositions which must be fulfilled to compensate zero drift. The first presupposition is that the reference pressure must have a constant pressure value. The second is that the reference voltage must be very stable and must correspond exactly to that voltage which would be the output voltage of the transducer in measuring the reference pressure value without zero drift.

This known system, therefore, has several disadvantages. First, it is difficult to maintain the reference pressure on a certain constant value. It is further necessary that the operator controls a reference voltage value which corresponds exactly to the value which the transducer would measure when it is connected to the certain reference pressure. For those reasons the known method and the known apparatus are complicated and may not lead to a high precise zero drift correction.

It is therefore the task of the present invention to provide a simple but very exact method and apparatus for automatically correcting the zero drift of a pressure transducer of the type mentioned above.

This task is solved according to the invention by the method as mentioned above, which is characterized in that the transducer is provided in the form of a capacitance manometer and is connected to a reference pressure at a time when this pressure is at least an order of magnitude less than the minimum pressure readable with the transducer and that then the correction factor is generated by storing the measured reference pressure value and that said stored value is subtracted from the values measured in subsequent readings of the transducer.

This task is further solved by an apparatus as mentioned above which is characterized in that the transducer is a capacitance manometer, that the reference pressure device is a pump for producing a pressure at least an order of magnitude less than the minimum readable pressure of the capacitance manometer and that said means for generating the correction factor comprises a computer connected to the control means and having storage means for storing the value measured in said second valve position as the correction factor and further comprises a subtractor for subtracting said stored correction value from values measured in said first valve position.

Preferred embodiments of the invention are described in the subclaims.

The figure illustrates in block diagram form a preferred embodiment of the present invention.

Referring to the figure, there is shown the capacitance manometer 11 of the present invention. The capacitance manometer 11 is the most accurate type of manometer made for measuring low pressures or vacuums and is obtainable from several vendors, one of which is the MKS Corporation. It is basically a parallel plate capacitor wherein one plate is a thin flexible metal membrane. One side of the membrane sees a vacuum and the other side sees the gas whose pressure is to be measured. Differences in degree of vacuum of each side of the membrane cause it to flex accordingly, changing the capacitance to provide an output voltage representative of the pressure of the gas being measured. Such manometers typically read vacuums down to 0.133 Pa (10^{-3} Torr).

However, these nanometers are subject to zero drift which causes inaccuracies in true pressure readings. This zero drift is caused by hysteresis relaxation caused by over pressurization, temperature variation and RF pickup. However, the chief cause of zero drift in these manometers is chemical contamination, i.e., particles lodging on the metal membrane. Accumulation of such particles on the metal membrane seriously affects the value of the capacitance of the manometer and, therefore, its accuracy. Chemical contamination is a particular problem in plasma etching systems where the etching gases are particularly productive of contaminating particles.

The capacitance manometer 11 is normally connected to chamber 12 of a process module 13 via three way valve 14 where it continuously monitors the gas pressure in the chamber 12. The process module 13 has an inlet conduit 15 and an outlet conduit 16. Each of the inlet and outlet conduits 15 and 16 include valves 17 and 18, respectively. Thus, gas may be introduced and held in chamber 12, permitted to pass through chamber 12 or chamber 12 may be evacuated by applying suction to outlet conduit 16. In plasma etching of a silicon wafer, chamber 12 is evacuated and then the etching gas introduced

and flows through chamber 12 for the time necessary to complete the etching of a silicon wafer which is disposed within chamber 12. During this time the chamber is maintained at a predetermined pressure by control of the degree of openings of valves 17 and 18. At the same time the gas is ionized to the degree necessary to obtain good etching results. In etching as well as other processes the pressure of the gas within chamber 12 is critical.

The valve 14 which in a first position connects capacitance manometer 11 to process module 13 has a second position which disconnects capacitance manometer 11 from process module 13 and connects it to diffusion pump 19.

Diffusion pump 19 is effective only at pressures below 26.6 Pa (2×10^{-1} Torr.). Thus, a mechanical pump 20 is used to pump diffusion pump 19 to a pressure below 26.6 Pa (2×10^{-1} Torr).

A Penning Ionization sensor 21 is connected to diffusion pump 19 and functions to determine when diffusion pump 19 is operating efficiently.

When the Penning Ionization sensor 21 indicates that the diffusion pump is operative and the capacitance manometer reads a pressure in chamber 12 in the region of 26.6 Pa (2×10^{-1} Torr), the valve 14 is moved to the second position, isolating chamber 12 from and connecting diffusion pump 19 to the capacitance manometer 11. The diffusion pump 19 then pumps down to a pressure of 1.33×10^{-3} Pa (1×10^{-5} Torr). Since the capacitance manometer 11 then sees a pressure at least an order of magnitude less than it is capable of reading, any output or indication it may have about its minimum readable pressure is an error. This is the correction which must be subtracted from the reading of the capacitance manometer 11 for subsequent monitoring of pressure in the chamber 12 of process module 13. This procedure may be repeated periodically to provide an updated correction factor for the capacitance manometer 11 whose zero drift may increase with time.

The capacitance manometer 11 provides a voltage representative of sensed pressure which may be fed directly to a meter (not shown) to provide a visual indication of measured pressure. Thus, when the valve 14 is in the second position the meter indicates the correction factor and when the valve 14 is in the first position the meter indicates the pressure in the chamber 12. From this pressure, the correction factor is subtracted to provide true reading of the pressure in chamber 12.

The output of the capacitance manometer 11 is connected to a subtractor circuit 23 which is connected to an analog to digital converter 24. The output of the analog to digital converter is connected to a computer 25.

The computer 25 has an output connected to a CRT display 26 and to a storage unit, e.g., a disc memory 27.

An output of the computer 25 is also connected to control 28 which controls operation of valve 14.

The computer 25 has a further output connected to digital to analog converter 29 which is connected to subtractor 23.

The computer 25 comprises essentially a memory and process controller which provides control outputs in accordance with a simple program routine.

The program routine of the computer 25 for carrying out comprises the following steps:

1. Read the capacitance manometer—is pressure near 13.3 Pa (10^{-1} Torr)?
2. Read the Penning sensor—is pressure near 1.33×10^{-3} Pa (10^{-5} Torr)?
3. If yes, direct the capacitance manometer to the diffusion pump if Penning sensor indicates diffusion pump is operative.
4. Read and store correction factor.
5. Direct capacitance manometer to process module.
6. Read pressure in process module.
7. Subtract correction factor from capacitance manometer reading of process module and store and display on CRT at request of operator.
8. Repeat cycle at predetermined time intervals and store each new correction factor in permanent memory.

The particular programming language into which the above program is translated, of course, is dependent upon the type of computer used.

When the capacitance manometer 11 is connected to the diffusion pump for a short time, its output which is the correction factor, is converted into digital form and stored in computer 25. It is also stored in a permanent memory, e.g., disc memory 27, which keeps a history of each correction factor determined during a cycle of the system.

This information provides an indication of the deterioration rate of the capacitance manometer 11 and is useful in determining the appropriate time when a particular capacitance manometer needs to be replaced.

The correction factor is also applied to subtractor 23 via digital to analog connector 29. The subtractor 23 subtracts the correction factor from the subsequent readings by the capacitance manometer 11 of process module pressure. These corrected readings are then converted to digital form in analog to digital converter 29 and stored in computer 25. The corrected readings may also be read out on CRT 26 at operator command.

The input to computer 25 from the Penning sensor 21 via analog to digital converter 24 functions as indicated above to prevent connection of the capacitance manometer 11 to the diffusion pump 19 until the Penning sensor 21 indicates the diffusion pump 19 is operative.

It should be noted that the diffusion pump 19 may be replaced with an ion pump which is smaller and functions in the same manner in the system as the diffusion pump 19. A sorption pump or a turbomolecular pump may also be used in place of the diffusion pump 19.

The computer 25 controls operation of the valve

14 via control 28 in accordance with the above outlined program.

In an actual etching process with which this invention may be used valve 17 is held closed while the chamber 12 is ruffed, i.e., brought down to a relatively low pressure by means of a pump (not shown) communicating with chamber 12 via open valve 18. This cleans the chamber 12 of previous etching gases and contaminants. Valve 18 is then closed, and etching gases are introduced into chamber 12 via valve 17. Applicant's system functions to monitor the pressure of the etching gases in the chamber 12, the value of which during the etching process is critical.

However, it should be pointed out that the present invention is not limited to wafer etching and is useful in any situation wherein a capacitance manometer is used to monitor very low pressures.

Other modifications of the present invention are possible in light of the above description which should not be deemed as limiting this invention beyond those limitations set forth in the claims which follow.

Claims

1. Method for automatically correcting the zero drift of a pressure transducer including the steps of automatically connecting the transducer to a reference pressure, measuring said reference pressure, using the measured value for generating a correction factor and applying said correction factor to a subsequent readings of the transducer characterized in that the transducer is provided in the form of a capacitance manometer and is connected to a reference pressure at a time when this pressure is at least an order of magnitude less than the minimum pressure readable with the transducer and that then the correction factor is generated by storing the measured reference pressure value and that said stored value is subtracted from the values measured in subsequent readings of the transducer.

2. Apparatus for automatically correcting zero drift of a pressure transducer (11) comprising a valve (14) connecting in a first position the pressure transducer (11) to a pressure to be measured and connecting in a second position the pressure transducer (11) to a reference pressure device (19, 20), control means (28) actuating said valve, means (25) for recording the measured pressure value in said second position and means (23, 24, 25) for generating a correction factor characterized in that the transducer is a capacitance manometer (11), that the reference pressure device is a pump (19, 20) for producing a pressure at least an order of magnitude less than the minimum readable pressure of the capacitance manometer (11) and that said means (23, 24, 25) for generating the correction factor comprises a computer (25) connected to the control means (28) and having storage means for storing the value measured in said second valve position as the correction factor and further comprises a subtractor (23) for subtracting said stored correction value from values measured in said first valve position.

3. Apparatus according to claim 2, characterized in that said pump is a diffusion pump (19).

4. Apparatus according to claim 2, characterized in that said pump is an ion pump.

5. Apparatus according to claim 2, characterized in that said pump is a turbomolecular pump.

6. Apparatus according to claim 2, characterized in that said pump is a sorption pump.

7. Apparatus according to claim 3, characterized in that a mechanical pump (20) is connected to the diffusion pump (19).

8. Apparatus according to claim 4, characterized in that a mechnical pump is connected to said ion pump.

9. Apparatus according to claim 7 or 8, characterized in that sensor means (21) is connected to said pump (19).

10. Apparatus according to any one of claims 2 to 9, characterized in that it includes a process module (13) containing a chamber (12) whose pressure is to be monitored by the capacitance manometer (11) and that said valve (14) connects the capacitance manometer (11) to said process module (13) in said first valve position.

11. Apparatus according to any one of claims 2 to 10, characterized in that display means (26) are provided for displaying the corrected pressure read by the capacitance manometer.

12. Apparatus according to claim 9 or claims 10 and 11 when dependent from claim 9, characterized in that the computer (25) is connected to the sensor means (21).

Patentansprüche

1. Verfahren zum automatischen Berichtigen der Nullpunktverschiebung eines Druckwandlers, bei dem der Wandler automatisch an einen Bezugsdruck angeschlossen und der Bezugsdruck dann gemessen wird und wobei der Meßwert zur Erzeugung eines Korrekturfaktors verwendet wird, der bei den nachfolgenden Messungen des Wandlers berücksichtigt wird, dadurch gekennzeichnet, daß der Wandler ein kapazitiver Druckmesser ist und an den Bezugsdruck zu einer Zeit angeschlossen wird, wenn dieser Druck um wenigstens eine Größenordnung kleiner als der minimale Druck, den der Wandler messen kann, ist und daß dann der Korrekturfaktor erzeugt wird, in dem der gemessene Bezugsdruckwert gespeichert wird und daß der gespeicherte Wert von den Werten, die in nachfolgenden Messungen des Wandlers gemessen werden, abgezogen wird.

2. Gerät zum automatischen Berichtigen der Nullpunktverschiebung eines Druckwandlers (11) mit einem Ventil (14), welches in einer ersten Stellung den Druckwandler (11) an den zu messenden Druck anschließt und in einer zweiten Stellung den Druckwandler (11) mit einer Bezugsdruckanordnung (19, 20) verbindet, mit einer

Steuereinheit (28), die das Ventil betätigt, mit einer Einrichtung (25) zum Aufzeichnen des gemessenen Druckwertes in der zweiten Stellung und einer Einrichtung (23, 24, 25) zur Erzeugung eines Korrekturwertes, dadurch gekennzeichnet, daß der Wandler ein kapazitives Manometer (11) ist und daß die Bezugsdruckanordnung eines Pumpe (19, 20) ist, die einen Druck erzeugen kann, der wenigstens um eine Größenordnung kleiner als der minimale Wert, den das kapazitive Manometer (11) messen kann, ist und daß die Einrichtung (23, 24, 25) zur Erzeugung des Korrekturfaktors einen Rechner (25) umfaßt, der mit der Steuereinheit (28) verbunden ist und einen Speicher aufweist, in dem der in der zweiten Ventilstellung gemessene Wert als Korrekturwert gespeichert wird und wobei die Einrichtung weiterhin eine Subtraktionseinheit (23) aufweist, mit der der gespeicherte Korrekturwert von den Werten, die in der ersten Ventilstellung gemessen werden, abgezogen wird.

3. Vorrichtung nach Anspruch 2, dadurch gekennzeichnet, daß die Pumpe eine Diffusionspumpe (19) ist.

4. Vorrichtung nach Anspruch 2, dadurch gekennzeichnet, daß die Pumpe eine Ionenpumpe ist.

5. Vorrichtung nach Anspruch 2, dadurch gekennzeichnet, daß die Pumpe eine Turbomolekularpumpe ist.

6. Vorrichtung nach Anspruch 2, dadurch gekennzeichnet, daß die Pumpe eine Saugpumpe ist.

7. Vorrichtung nach Anspruch 3, dadurch gekennzeichnet, daß eine mechanische Pumpe (20) mit der Diffusionspumpe (19) verbunden ist.

8. Vorrichtung nach Anspruch 4, dadurch gekennzeichnet, daß eine mechanische Pumpe mit der Ionenpumpe verbunden ist.

9. Vorrichtung nach Anspruch 7 oder 8, dadurch gekennzeichnet, daß eine Sensoreinrichtung (21) mit der Pumpe (19) verbunden ist.

10. Vorrichtung nach wenigstens einem der Ansprüche 2 bis 9, dadurch gekennzeichnet, daß sie einen Steuermodul (13) umfaßt, der eine Kammer (12) beinhaltet, deren Druck von dem kapazitiven Manometer (11) gemessen wird und daß das Ventil (14) das kapazitive Manometer (11) mit dem Steuermodul (13) in der ersten Ventilstellung verbindet.

11. Vorrichtung nach einem der Ansprüche 2 bis 10, dadurch gekennzeichnet, daß eine Anzeigeeinrichtung (26) vorgesehen ist, die die korrigierten Druckwerte des kapazitiven Manometers anzeigt.

12. Gerät nach Anspruch 9 oder nach den Ansprüchen 10 und 11, wenn diese von Anspruch 9 abhängen, dadurch gekennzeichnet, daß der Rechner (25) mit der Sensoreinrichtung (21) verbunden ist.

Revendications

1. Procédé pour corriger ou compenser automatiquement le glissement du zéro d'un transducteur de pression consistant à relier automatiquement la transducteur à une source de pression de référence, à mesurer la pression de référence, à utiliser la valeur mesurée pour engendrer un facteur de correction et à appliquer le facteur de correction aux lectures ultérieures du transducteur, caractérisé en ce que le transducteur est prévu sous la forme d'un manomètre capacitif et connecté à une source de pression de référence au moment où cette pressure est au moins de l'ordre de grandeur inférieur à la pression minimale lisible avec le transducteur, en ce que le facteur de correction est ensuite engendré en mémorisant la valeur de pression de référence mesurée et en ce que la valeur mémorisée est soustraite des valeurs mesurées dans les lectures ultérieures du transducteur.

2. Dispositif pour corriger ou compenser automatiquement le glissement du zéro d'un transducteur de pression (11) comprenant une soupage (14) reliant dans une première position le transducteur de pression (11) à une source de pression à mesurer et reliant dans une seconde position le transducteur de pression (11) à une source de pression de référence (19, 20), un moyen de commande (28) actionnant la soupape, un moyen (25) pour enregistrer la valeur de pression mesurée dans la seconde position et des moyens (23, 24, 25) pour engendrer un facteur de correction, caractérisé en ce que le transducteur est un manomètre capacitif (11), en ce que la source de pression de référence est une pompe (19, 20) pour produire une pression au moins de l'ordre de grandeur inférieur à la pression minimale lisible du manomètre capacitif (11) et en ce que les moyens (23, 24, 25) pour engendrer le facteur de correction comprennent un ordinateur (25) connecté au moyen de commande (28) et comportant une mémoire pour mémoriser la valeur mesurée dans la seconde position de soupape comme le facteur de correction et en ce qu'il comprend en outre un soustracteur (23) pour soustraire la valeur de correction mesurée des valeurs mesurées dans la première position de soupape.

3. Dispositif selon la revendication 2, caractérisé en ce que ladite pompe est une pompe à diffusion (19).

4. Dispositif selon la revendication 2, caractérisé en ce que la pompe est une pompe ionique.

5. Dispositif selon la revendication 2, caractérisé en ce que la pompe est une pompe turbomoléculaire.

6. Dispositif selon la revendication 2, caractérisé en ce que la pompe est une pompe à sorption.

7. Dispositif selon la revendication 3, caractérisé en ce qu'une pompe mécanique (20) est connectée à la pompe à diffusion (19).

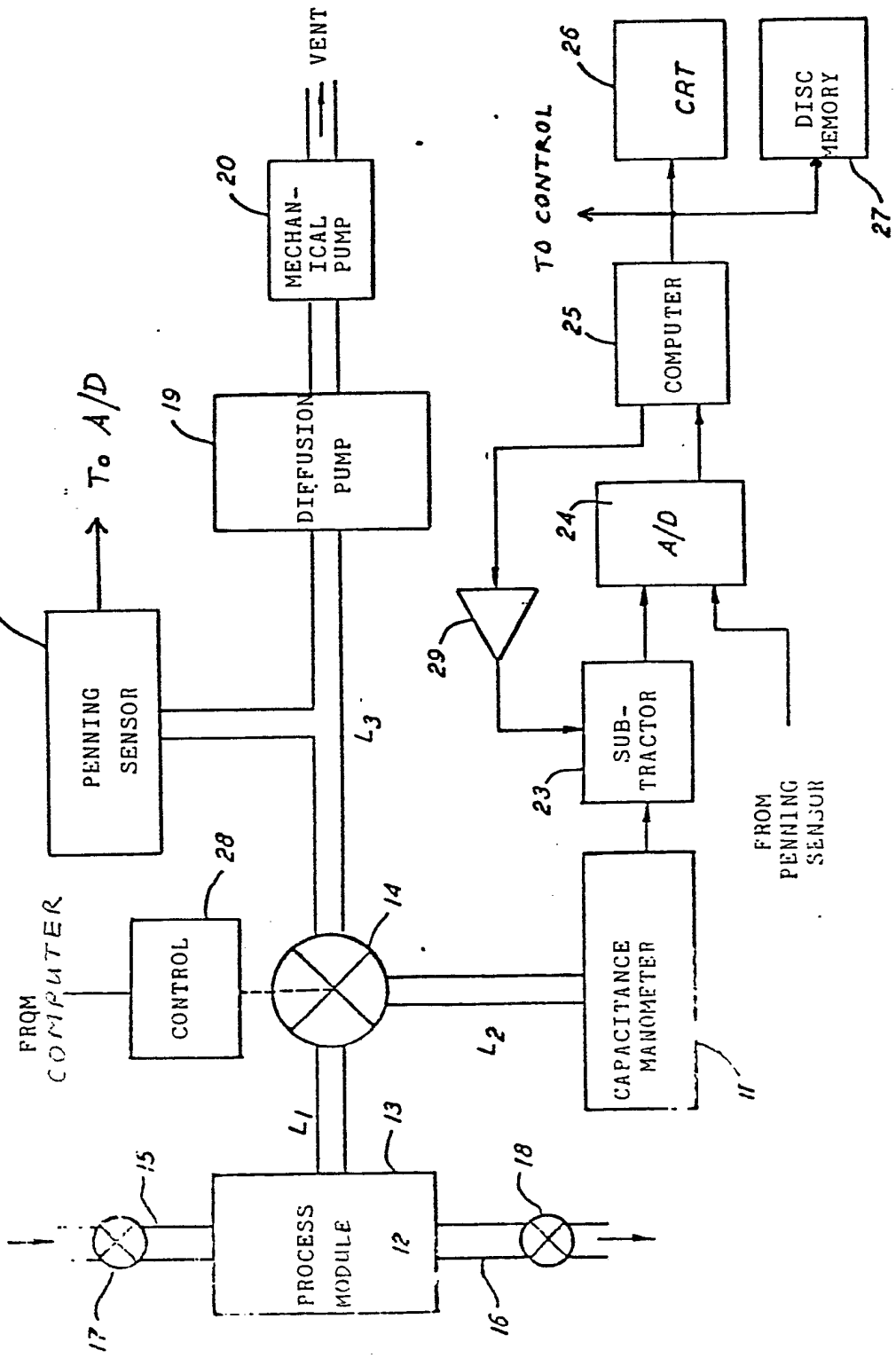
8. Dispositif selon la revendication 4, caractérisé en ce qu'une pompe mécanique est connectée a6 la pompe ionique.

9. Dispositif selon l'une quelconque des revendications 7 et 8, caractérisé en ce que le capteur (21) est connecté à la pompe (19).

10. Dispositif selon l'une quelconque des revendications 2 à 9, caractérisé en ce qu'il comprend un module de traitement (13) contenant une chambre (12) dont la pression doit être contrôlée par la manomètre capacitif (11) et en ce que la soupape (14) relie le manomètre capacitif (11) au module de traitement (13) dans la première position de soupape.

11. Dispositif selon l'une quelconque des revendications 2 à 10, caractérisé en ce qu'un moyen de visualisation (26) est prèvu pour visualiser la pression corrigée lue par le manoemètre capacitif.

12. Dispositif selon la revendication 9 ou les revendications 10 et 11 quand elles sont dépendantes de la revendication 9, caractérisé en ce que l'ordinateur (25) est connecté au capteur (21).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20
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